ECOBOX - MFC150

Product Manual

METHANOL REFORMER SYSTEM

Updated Aug 8, 2015

ECOBOX-MFC150_UM_V2.7

Disclaimer

This manual incorporates safety guidelines and recommendations. However, it is not intended to cover all situations. It is the responsibility of the customer to meet all local safety requirements and to ensure safety during operation, maintenance and storage of the ECOBOX-MFC150 system.

Although all efforts have been made to ensure the accuracy and completeness of the information contained in this document, Horizon reserves the right to change the information at any time and assumes no liability for its accuracy.

Actions that will void the fuel cell system warranty:

- Attempting, under any circumstance, to disassemble or inappropriately tamper with the system.
- Disassembling the system.
- Operating the system in a manner which is not anticipated in the system setup and/or specified in the user manual provided for the specific product.
- Damage to the system caused by misuse, physical abuse or neglect.
- The ECOBOX-MFC150 system uses IMPCA-grade Methanol blend of 62.5% methanol, 37.5% distilled, deionized and demineralized water by weight. If a purified Methanol Blended fuel is not available in your location, please use only pure distilled water and IMPCA -grade Industrial pure methanol to make it.

Do not attempt, under any circumstance, to disassemble or inappropriately tamper with the system. There will be no repair, replacement or refund should disassembly or tampering occur. If you have questions or need help with regards to the system and its technology,
please contact:
support@horizonfuelcell.com

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1. Important Safety Information

Please read all instructions carefully prior to product use and keep this manual with or near the system for future reference.

The safety guidelines included here may not cover every situation. Use common sense and caution at all times when working on or near the system.

- DO NOT SMOKE in the vicinity of the system or the fuel.
- DO NOT WELD in the vicinity of the system or the fuel.
- DO NOT ALLOW ANY NAKED FLAME in the vicinity of the system or the fuel.
- DO NOT DRINK the Methanol Fuel – it is a poison which WILL BLIND you and may KILL you.

Wear Personal Protective Equipment when handling the Methanol Fuel – Latex Gloves, Safety Eye Protection and Class 2 face mask.

Although the Methanol reformer systems are designed with simple, easy-to-use interfaces, prudent safety measures should be followed.

1.1 General information

For this unit to generate electrical power, a supply of methanol is necessary. It is important for any operator to be aware of, understand, and follow all local safety requirements related to the handling of methanol. Ensure that your facility conforms to all local regulatory requirements, including building codes, storage and safety recommendations.

The methanol reformer system has built-in safeguards and is designed to shut down automatically if any out of range operating condition occurs. Possible situations include low cell voltage, fuel leakage, high temperature, and low fuel level.

- Do not operate the system on a grade of more than 35 degrees.
- Do not connect or disconnect power cables when the system is energized.
- Do not move the system when the system is running.
- Do not dismantle the system. Contact Horizon if you have any concerns about operation.

1.2 Using Methanol

The ECOBOX-MFC150 system uses 62.5% methanol, 37.5% distilled, de-ionised water. If you can not access prepared fuel from your Horizon agent or a reliable local supplier, you can mix the fuel yourself if you exercise caution. Contact your Horizon agent or the Methanol Institute for specific instructions and training on safe management of the fuel mixing process.
Do not breathe the vapour, do not allow Methanol to contact with clothing or skin, do not ingest or drink the methanol, and avoid any release into drains or waterways. Please use only distilled, de-ionised water and Industrial pure methanol to make it.

Methanol Emergency Response - Medical and Safety

- **Symptoms of acute methanol exposure may include headache, weakness, drowsiness, nausea, difficult breathing, drunkenness, eye irritation, blurred vision, loss of consciousness, and possibly death.**
- **Patients may appear to improve and then get worse again up to 30 hours later.**
- **In case of methanol contact with skin, remove any contaminated clothing, wash with soap and water for 15 minutes, and seek medical attention if irritation occurs.**
- **If methanol comes in direct contact with eyes, immediately flush eyes with copious amounts of tepid water for at least 15 minutes. The patient should be taken to a health care facility and referral to an ophthalmologist considered.**
- **In case of inhalation of methanol vapors, remove individual to fresh air. Asphyxiation from vapors may require artificial respiration. Seek immediate medical assistance**
- **Ingestion of methanol is life threatening. Onset of symptoms may be delayed for 18 to 24 hours after ingestion. If patient is conscious, immediately give two glasses of water and induce vomiting. Do not make an unconscious person vomit. Transport immediately to a health care facility where standard methanol ingestion treatment can be administered.**

WARNING! FIRE OR EXPLOSION
Keep all sources of ignition away from Methanol.
Always operate the system in a well-ventilated area and ensure that ventilation slots are unobstructed. Be aware of localized sources of combustion such as gas fired water heaters and space heating units which can start on demand.

WARNING
The MFC150 uses methanol. Methanol is poisonous to humans. Less than 30ml (1oz) ingested or swallowed may cause irreversible blindness and may kill a person.
Methanol is a colorless alcohol, hygroscopic and completely miscible with water, but much lighter (specific gravity 0.8). It is a good solvent, but very toxic and extremely flammable. This simple single-carbon alcohol is a volatile solvent and a light fuel.

The particular hazards of methanol that matter most to your facility depend in large part on how methanol is received and stored, how it is used, where it is used, and how much is stored and used at any given time. Failure to control hazards associated with a small amount of methanol can be problematic with virtually no consequence; loss of control of a large quantity can be catastrophic.

1.3 Handling Methanol

WARNING

Do not handle methanol without training or experience.

Five overriding considerations are important when handing methanol:

- Methanol is a toxin; ingestion of a small amount (between one and two ounces, approximately 30 to 60 milliliters) may cause death; lesser amounts are known to cause irreversible blindness. Do not swallow methanol liquid, and do not allow vapor or liquid to contact skin. Methanol absorbs through the skin and other tissues directly into the blood stream.
- Methanol is a flammable, easily ignited liquid that burns and sometimes explodes in air.
- The molecular weight of methanol vapor is marginally greater (denser) than that of air (32 versus 28 grams per mole). As a result, and depending on the circumstances of a release or spill, ***methanol liquid will pool and vapor may migrate near the ground and collect in confined spaces and low-lying areas.*** It is expected that methanol vapor, being nest neutral buoyancy, will dissipate readily from ventilated locations. Do not expect it to dissipate from non-ventilated locations such as sewers and enclosed spaces. If ignited, methanol vapor can flash back to its source.
- In certain specific circumstances, methanol vapor may explode rather than burn on ignition. Methanol containers are subject to Boiling Liquid Expanding Vapor Explosion (BLEVE) when heated externally.
- Methanol is totally miscible in water and retains its flammability even at very high concentrations of water. A 75% water and 25% methanol solution is considered to be a flammable liquid. This has important consequences for firefighting. Methanol is a chemical solvent, which has important implications for materials selection and also for firefighting.

1.4 Methanol Storage- Portable Containers (Totes and Drums)

Totes and drums can be problematic. The methanol industry has gone to considerable lengths to design and fabricate satisfactory totes that are easily obtainable. Because the number of users of tote and drums far outnumbers the number of facilities with dedicated bulk storage and handling systems, this manual stresses the importance of safe methanol handing for tote and drum containment. It is strongly suggested that handlers consult methanol providers concerning their selection of containment. Unlike tank farms, where personnel seldom have direct contact, users of totes and drums are typically subject to spillage, need for immediate response, and subsequent cleanup.

The following provisions are suggested for tote, drum, and can users:

- Methanol should be purchased only from reputable sources.
- Providers should be consulted regarding the intended application and circumstances of use before committing to a sales contract. Many merchant chemical companies are equipped and willing to extend their services in order to assure safe use of the chemicals they sell.
- After agreeing on facilities and provisions for receiving, storage, and local transfer, establish and train a local response team in the actions that are necessary and prudent in the event of a spill.
- Certain aspects of methanol handing require special provisions and protective measures. These include the following:
  - As much as possible, methanol should be stored and used in a dedicated area that is specifically marked off and appropriately labeled. This area should have safety measures readily available to employees working in the area. The area should be designated as a hazardous area, and protective measures should be immediately available in the event of spillage, exposure, and ignition.
  - The area designated for methanol handing should be equipped with an effective audible alarm, which will summon assistance in a timely manner.
  - Use positive materials identification for gaskets, filters, hose material, and similar supplies which will be in contact with the Methanol fuel.
  - Replace gaskets, hoses, and “O” rings periodically, before they are expected to degrade or fail.
  - Ensure that procedures are in place to ground Methanol tanks and containers, and periodically verify grounding.
  - Ensure that procedures are in place to protect against water uptake and accumulation.
  - Ensure that provisions and procedures are in place to prevent spilled methanol from entering drains, manholes, and confined spaces.
  - Ensure that procedures and provisions are in place for preventing methanol entry into the water table or aquifers.
  - Ensure that procedures and equipment are in place for personnel protection and exposure mitigation. This should include eye wash and shower stations.
  - Ensure that procedures and equipment are in place for leak detection and alarm.
  - Ensure that procedures and equipment are in place for onsite emergency response.
  - Ensure that procedures and possibly specialized equipment are in place for offsite emergency responders.

1.5 Electrical Classification

Electrical equipment within the proximity of methanol storage and handing must be explosion proof to meet National Electrical Code (NEC) requirements [42]. Positive pressure may be required to ensure that methanol-free areas, such as smoking rooms and control systems and electrical switch gear, are protected.

1.6 Grounding and Bonding

Grounding is especially important in protecting methanol from accidental ignition resulting from static discharge. Methanol is polar compound. In general, methanol storage is not expected to accumulate static charge. However, circumstances such as a tank with a non-conductive liner can change the rate of charge accumulation.

It is recommended that grounding straps be equipped with carbide-tipped clamps to ensure electrical contact through nonconductive surface coatings, such as paint. Tanks and storage vessels should be fitted with dip-tube-filling to protect against ignition from static electricity generated as a result of liquid falling through air.

Grounding is required for lighting systems, pipe racks, pumps, vessel, filters, and all other equipment near and potentially within range of methanol vapor. Tall towers and other equipment subject to lighting strike must be equipped with lightning arresters.

Hoses must be grounded. In methanol loading and unloading situations, the possibility of spark generation due to accumulation of static electricity is less than with materials such as low sulfur diesel. Methanol is not a static accumulator. Electrical conductivity of methanol is relatively high when compared to that of most fuel materials. Nevertheless, velocity limits should be placed on transfer operations that involve high pressure drop, hydraulic impacts, and erosion concerns. Refer to API and NFPA publications for specific guidance.

Bonding is a measure intended to dissipate static electricity generated during fluid transfer through a conductive or nonconductive material. It involves making a connection between a grounded object and an ungrounded object. Methanol transfer operations should be bonded and grounded.

Metal containers (drums or totes) and the associated fill equipment pump should be bonded together and grounded during methanol transfer operations. Fill pipes or hoses should be conductive and should be bonded to the filling system. Bonding should be done with a 1/8-inch bare stainless steel cable connected to a clamp with hardened steel points and screws or a strong spring that will penetrate paint, corrosion, and accumulated materials. Apply the bonding clamp on the top chime of drum containers prior to removing the bung. Extend the pipe to within one inch (25 mm) of the bottom of the container. Start pouring slowly (at less than one meter per second or a container fill rate of less than 2 inches or 5cm of fluid level rise per minute) until the container is filled to a level equivalent to two pipe diameters up the side of the fill pipe.

In recent years, attention has been drawn to the hazard of using personal electronic items, such as cell phones, laptop computers, etc., in environments subject to potentially explosive atmospheres, e.g., gasoline stations, and fueling terminals. The energy necessary to ignite gasoline vapors (0.2mJ at the optimum mixture ratio for combustion) is similar to the energy produced by static electricity

and by sparks generated by low-voltage electrical devices when they are turned on. It is not considered good practice to operate electronics such as cell phones and laptop computers in a potentially flammable atmosphere.

Be aware of the following:

- Mobile phones can ignite fuel fumes from gasoline, ethanol, methanol, propane, and compressed natural gas (CNG).
- Mobile phones that light up when switched on or when they ring release enough energy to provide a spark capable of igniting hydrocarbon vapors.
- Mobile phones should not be used (should be turned off) in filling stations, fuel terminals, or when filling portable containers, fueling lawn mowers, boats, etc.
- Mobile phones should not be used (should be turned off) around materials that generate flammable or explosive fumes (e.g., solvents, chemicals, gases).

The same precautions apply for laptop computers, flashlights, battery lanterns, and other battery-operated devices should not be used within 20 feet (7 meters) of a potentially explosive atmosphere. This distance is sufficient to provide a buffer of distance between the potential source of ignitable fumes and the device. Increase this distance to 50 feet (17 meters) for pressurized liquid gases, such as propane.

When dispensing from a metal container, the container and the associated fill equipment, including dip pipes, conductive hose, and pump, should be bonded together and grounded. Plastic-lined metal containers with epoxy or phenolic coatings less than 2mm thick can be treated as metal containers. If the liner is more than 2 mm thick, the container should be treated as non-conductive. When handing methanol, treat non-conductive containers as if both the container and the methanol are non-conductive.

Plastic containers cannot be grounded and should not be used for Class I Flammable liquids, such as methanol, without expert review, as per NFPA 30, Flammable and Combustible Liquids. If a plastic container must be used, follow the same procedure as for metal containers.

1.7 Terminology

PEM fuel cell:

A PEM (Proton Exchange Membrane) fuel cell is a device that converts hydrogen and oxygen into water and electricity.

Reactants:

Reactant is a material used to start a chemical reaction. In the fuel cell the reactants are air and hydrogen by which the electricity will be generated.

Humidification:

Humidity, the fuel cells need a certain level of Humidity for running.

Blower:

Supply air to the fuel cells and meanwhile decrease the temperature in the stack.

Mass flow per minute:

The total amount of the hydrogen flow through the fuel cell every minute, which the hydrogen supply can be calculated.

HFCT:

Horizon Fuel Cell Technologies

2. User Manual

2.1 Introduction

Thank you for choosing Horizon's ECOBOX-MFC150 METHANOL REFORMER SYSTEM as your power generating solution. Based on Horizon's expertise in modular, redundant fuel cell systems, the ECOBOX-MFC150 is the next step in simplicity, scalability, modularity and reliability, providing clean, quiet, and reliable power for backup power applications.

2.2 About This Manual

This manual is intended to provide customers with all the information needed to select, install, operate, maintain, and troubleshoot an ECOBOX-MFC150 system.

2.3 PEM Technology

While there are a number of fuel cell technologies available, the most common and practical technology for standby power is the proton exchange membrane, or PEM, fuel cell.

The only inputs to the fuel cell are industrial Grade 3.5 hydrogen (99.95% H2 concentration) and oxygen (air), with the only byproducts being pure water/vapor and heat. As a result, fuel cells are considered a green technology, making them an attractive solution for installations with emissions restrictions.

One of the other attributes of a fuel cell that makes it attractive for deployment in many applications is that a fuel cell produces DC power. This makes a fuel cell akin to a standby rectifier source, as the power provided from the fuel cell can be directly connected to the site's DC power bus. In an outage situation, the fuel cell turns on automatically, providing DC power, which was formerly provided by the rectifiers. DC output also makes the fuel cell ideally suited for hybrid applications with solar (photovoltaic), wind and battery systems.

The fuel cell is akin to a generator, in that the fuel cell is sized for the power requirement, and can run indefinitely provided it has a source of fuel. This means fuel cells, when coupled with an appropriately sized fuel storage solution, can function effectively for long reserve times as a standby power source in customer applications.

3. The ECOBOX-MFC150 System

This section describes the operating principles of the ECOBOX-MFC150 system. The ECOBOX-MFC150 system functions as a Methanol fueled Hydrogen Fuel Cell generation DC power source. The unit can be started and stopped manually or automatically. Because its electrical output is DC, the ECOBOX-MFC150 system can be installed directly in parallel with other DC equipment. The systems are available in a range of 11V to 14V DC version.

For proper operation, the ECOBOX-MFC150 system requires airflow. A source of clean air must be supplied. The exhaust air is humid, which may condense on cooler surfaces, and may contain trace hydrogen and CO2, and therefore should be vented outdoors. There is a small periodic fuel purge (or "bleed") that must also be vented outdoors. A minimum installation for basic operation requires the ECOBOX-MFC150 system to have all air exhausts and fuel inlet and outlet exhaust connections plumbed, and that the unit is connected to a DC bus at the appropriate voltage, with an appropriate load and suitable battery attached. A complete installation will include protection from weather and temperature. The system can be supplied mounted in an optional IP54 rated outdoor enclosure by Horizon. Horizon outdoor enclosures are specifically designed to house the fuel cell equipment and provide proper protection from weather and temperature.

Table 3-1 shows the specification of ECOBOX-MFC150 system. For detailed specifications, please see Appendix A.

Table 3-1 ECOBOX-MR Specifications

Model	Rated Power	Output Voltage	Detail Information
ECOBOX-MFC150	150W	11V to 14V	Appendix A

In a chassis-only configuration, the ECOBOX-MFC150 system is rated for indoor installation only. Indoor installations must be ventilated to outdoors.

For outdoor installation, the ECOBOX-MFC150 system may be mounted in a 19" or 23" 2-post rack or 4-post rack, which should be rated to IP54 or better.

In both indoor application and outdoor application, ECOBOX-MFC150 system must be kept away from flammable and explosive goods and places (such as the gas station), and the sewer drainage outlet, and chemical plants which may produce harmful gases, etc.

Locations where there is a high concentration of airborne pollution from traffic or industry, and particularly diesel or chemical fumes, should be avoided where possible; additional filtering of the incoming air should be used where such locations can not be avoided.

3.1 ECOBOX-MFC150 Models

- The front panel of ECOBOX-MFC150 system, please see figure3-1.

Figure 3-1. The front panel of ECOBOX-MFC150

- The rear panel of ECOBOX-MFC150 system, please see figure3-2.

Figure 3-2. The rear panel of ECOBOX-MFC150

WARNING
The temperature of Reformer Exhaust Outlet may reach 100 degrees. Please pay attention to safety.

3.2 Chassis System Features

WARNING

To avoid property damage, personal injury or loss of life, DO NOT attempt to operate this unit until all directions have been read and understood.

3.2.1 LCD Display

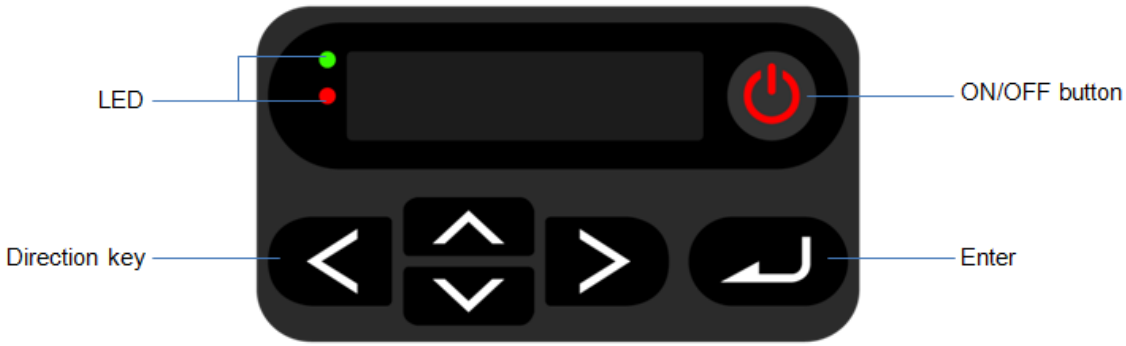

Figure 3-3. The LCD Display

3.2.1.1 ON/OFF button

- Press the button for 1 second to power on the system.
- After starting, press the button for 1 second to let the system enter to Hot Standby mode.
- During Hot Standby, press the button for 1 second to let the system enter to normal operation.
- Press the button for 3 seconds to shut down the system.
- During shutting down, push the button for 5 seconds to restart the system.

3.2.1.2 LED Indicator Light

Green:

- Lit during the normal operation.
- Flash during starting and Hot Standby mode.

Red:

- Lit when error happens.

3.2.1.3 Direction Key and Enter

- The direction key and enter can be used to set the system mode.
- The up and down key can be used to check the information during the normal operation.

3.2.2 LCD display information

- System operation status display
- System fault information

  If the system shut down because of an error, The LCD will continue to show the error information for 3 minutes. After 3 minutes, system will restart again automatically.
- Stack and battery parameter display

Table 3-2 Fault information

Display	Note	Solutions
FAULT!ERR CODE 2 STACK VOLTS LOW	The stack voltage is lower than <0.5V/Cell.	a) Check fuel level. b) Keep enough fuel supply.
FAULT!ERR CODE 3 STACK OVER CURR	The stack current is over 20A.	
FAULT!ERR CODE 5 STACK OVER TEMP	The stack temperature is over 68 degrees.	a) Avoid operating in an overheated environment.
FAULT!ERR CODE 20 INTERNALBATTLOWV	The battery voltage is lower than 10.5V.	a) Check the battery voltage. The voltage should between 12V to 14V. b) Charge the battery by an external power supply then restart.
FAULT!ERR CODE 41 LOW H2 PRESSURE	The buffer tank presser is lower than 0.3bar.	a) Check fuel level. b) Restart system.
FAULT!ERR CODE 42 HIGH H2 PRESSURE	The buffer tank presser is higher than 8bar.	a) Turn off the system and restart.
FAULT!ERR CODE 43 INTERNAL H2 LEAK	Hydrogen leakage occurs in the system.	a) Operate in a ventilated environment.
FAULT!ERR CODE 76 REFORMEROVERTEMP	The reformer temperature is higher than 610 degrees.	a) Avoid operating in an overheated environment.
FAULT!ERR CODE 77 REFORMEROVERTEMP	The reformer temperature is higher than 600 degrees.	a) Avoid operating in an overheated environment.
FAULT!ERR CODE 78 REFORMERLOWTEMP	The reformer temperature is lower than 2 degrees.	a) Check the battery voltage. The voltage should between 12V to 14V.
FAULT!ERR CODE 79 REFORMERLOWTEMP	The reformer temperature is lower than 350 degrees.	a) Check the battery voltage. The voltage should between 12V to 14V.
FAULT!ERR CODE 80 CAT HIGHPRESSURE	The catalyst pressure is higher than 20Bar.	
FAULT!ERR CODE 81 CAT LOW PRESSURE	The catalyst pressure is lower than 2Bar.	a) Check fuel level b) Keep enough fuel supply c) Keep fuel hose unhindered.

FAULT!ERR CODE 82 PURIFIEROVERTEMP	The purifier temperature is higher than 460 degrees.	a) Avoid operating in an overheated environment.
FAULT!ERR CODE 83 PURIFIEROVERTEMP	The purifier temperature is higher than 450 degrees.	a) Avoid operating in an overheated environment.
FAULT!ERR CODE 84 PURIFIERLOWTEMP	The purifier temperature is lower than 2 degrees.	a) Check the battery voltage. The voltage should between 12V to 14V.
FAULT!ERR CODE 85 PURIFIERLOWTEMP	The purifier temperature is lower than 320 degrees.	a) Check the battery voltage. The voltage should between 12V to 14V.
FAULT!ERR CODE 103 EEPROM FAULT	The storage fault.	
FAULT!ERR CODE 150 LOAD PROTECTION	Load protection. Load was shut down when two errors happen together.	
FAULT!ERR CODE 153 HEATING TIMEOUT	Catalyst heating time is more than 90 minutes when cold starting. Catalyst heating time is more than 60 minutes when warm starting.	a) Check the battery voltage. The voltage should between 12V to 14V.
FAULT!ERR CODE 156 P-RISING TIMEOUT	Pressure rising time is more than 30 minutes.	a) Check fuel level b) Check tank is not under vacuum c) Keep fuel hose unhindered.
FAULT!ERR CODE 157 HEATING2 TIMEOUT	Catalyst heating time is more than 20 minutes when system restart automatically for periodic maintenance.	a) Check the battery voltage. The voltage should between 12V to 14V.

If you have questions or need help with regards to the fuel cell and its technology contact: support@horizonfuelcell.com.

3.2.2.1 System Starting Process

Press the ON/OFF button to start the system, then the LCD display shows the system starting information (Welcome to Horizon, the firmware version number…). Press ENTER to continue when there was an error last time. The detailed system starting process please find in figure 3-4.

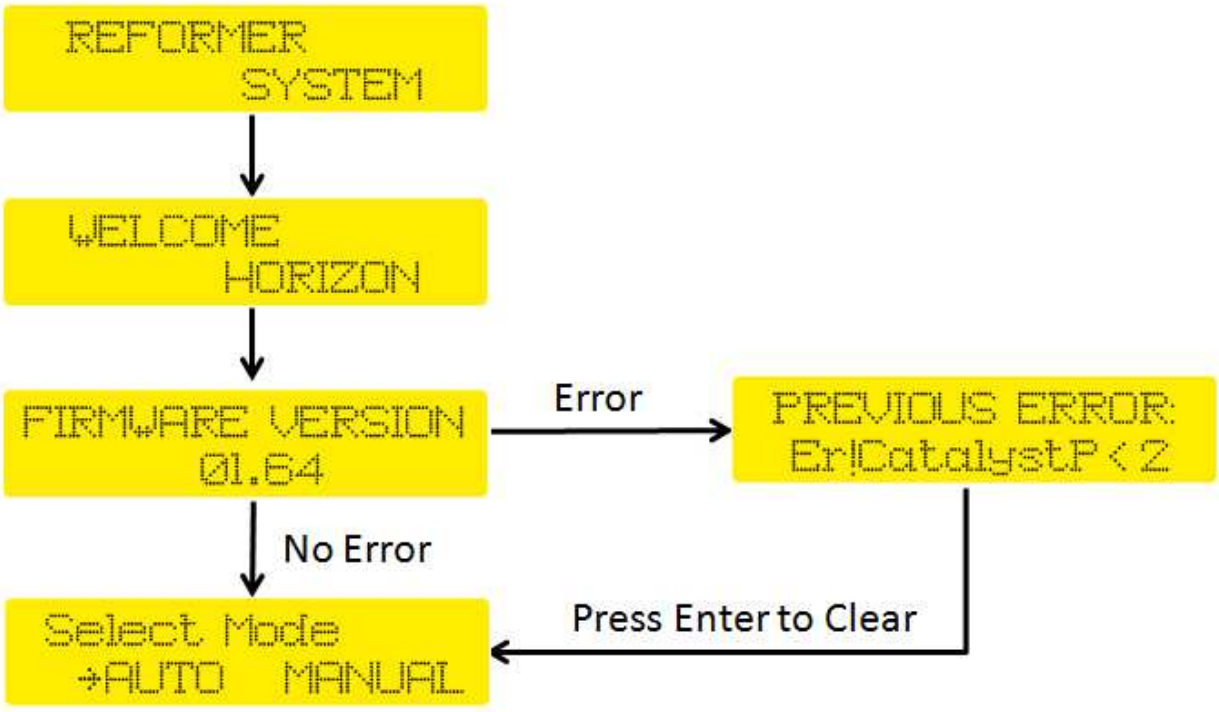

Figure 3-4. System starting process

3.2.2.2 Set System Mode

During the starting process, the customer can set the system mode. The ECOBOX-MFC150 system has two modes; Auto Mode, and Manual Mode. Use direction keys to choose the system mode setting. Press ENTER to enter into the system mode. Then use the direction keys and ENTER button to choose and set the mode. The detailed system mode setting process can be looked in figure 3-5. If there is no action within 5 seconds, the system will use the value which was set last time, and enter to the next step automatically.

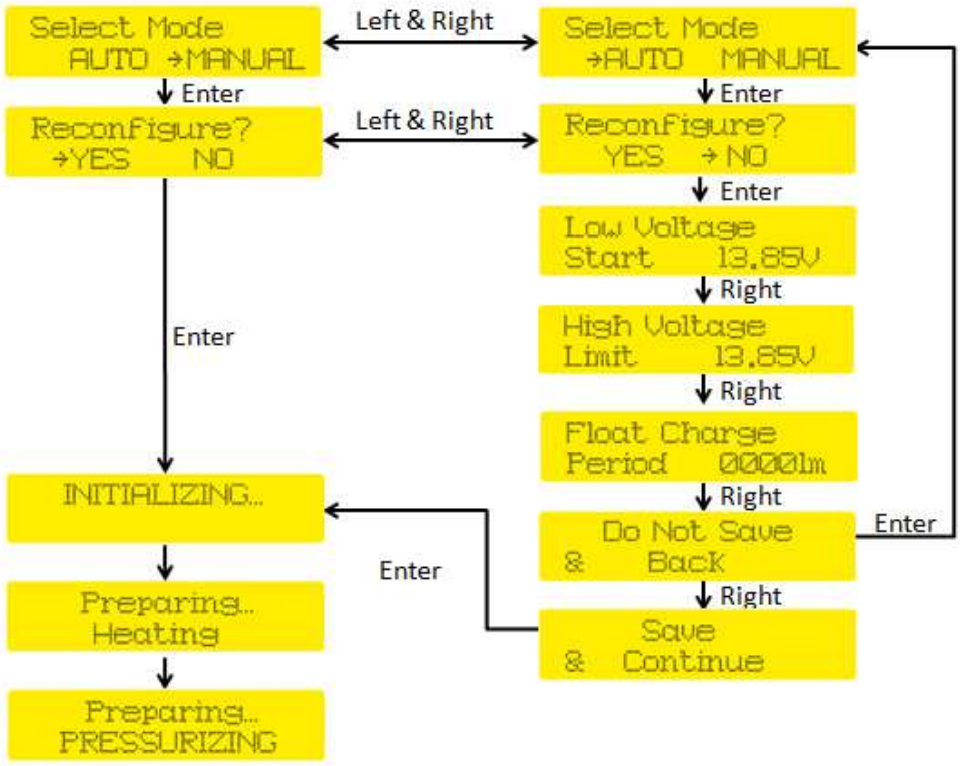

Figure 3-5. System Mode Setting Process

- System mode setting

There are two modes which are Auto Mode and Manual Mode. The customers can press left or right key to choose the system mode.

When setting the values in “Low Voltage Start”, “High Voltage Limit” and “Float Charge Period”, press Enter to let the cursor appear, and then use direction keys to choose and change the value.

1) Auto Mode

When the system starts in Auto mode, the unit will attempt to achieve an output voltage which is the value set in the “High Voltage Limit”. Once the system has achieved and held float voltage for a period of time (set in the “Float Charge Period”), the unit will return to Standby. This mode functions as a battery charge mode, charging up an external battery

to the “High Voltage Limit”, and then returning to Hot Standby. When the batteries discharge to the “Low Voltage Start”, the system will start again. This charge/discharge method is useful for very small loads, where the battery is properly sized to support the small load, and is recharged by the fuel cell. The fuel cell system will operate “thermostatically”, turning on at the “Low Voltage Start”, and turning off after holding the output at the “High Voltage Limit” setting until the “Float Charge Period” expires. When the bus voltage is held at or above the “High Voltage Limit” setting until the “Float Charge Period” expires, the unit will return to Standby and remain there, provided the bus voltage remains above the “Low Voltage Start”.

Auto mode is a useful option for off-grid hybrid systems that are relatively low power. The fuel cell is used to charge the batteries, and the batteries then carry the load for extended periods. The total system solution is most efficient for small loads that are <5% of the fuel cell capacity, with an appropriately sized battery.

When started in Auto mode, the fuel cell will deliver power until the output bus voltage reaches the user-set “High Voltage Limit” (whether because the unit has sufficient power to support the load and charge the batteries, or because the external power was restored). Once the “High Voltage Limit” is achieved, a user-adjustable “Float Charge Period” will start. When the “Float Charge Period” expires, the unit will stop delivering power and return to Standby.

“Low Voltage Start” in the user interface is used to set the voltage at which the system begins to operate when the Auto Mode is enabled. This voltage must be at least 0.5V below the value set in “High Voltage Limit”.

The “Low Voltage Start” range is from 11V to 13V.

“High Voltage Limit” in the user interface is used to set the voltage at which the system returns to Standby.

And the range of “High Voltage Limit” is from 13.5V to 14V.

“Float Charge Period” in the User Interface is used to set the timer that determines the end of the Auto mode.

“Float Charge Period” can be set from 0 to 200 minutes in 1 minute increments.

2) Manual Mode
When the system starts in manual mode, the system will keep running, and use the minimum current to float charge the battery. The front panel ON/OFF switch allows the user to manually turn the system on to generate power or to hot standby. And the only method to stop the unit is by pressing the switch again.

3.2.2.3 Operation Information

Table 3-3 Operation information

System phase	Display	Note
Startup	Preparing... Heating	System starting process
	Preparing... PRESSURIZING	
	T B380 P320 C385 P H0.50 C00.9 BAT 13.50V 00.0A	Press down key to check system information. "T" means temperature. "B380" means burner temperature is 380℃. "P320" means purifier temperature is 320℃. "C385" means catalyst temperature is 385℃. "P" means pressure. "H0.50" means hydrogen pressure is0.50Bar. "C00.9" means pump pressure is 00.9Bar. "BAT" means battery. And the followings are the battery voltage and current.
Normal operation	STK 16.00V 10.0A BAT 13.50V 00.0A	"STK" means stack. And the followings are the stack voltage and current. "BAT" means battery.
	T B380 P320 C385 P H0.50 C00.9	"T" means temperature. "B380" means burner temperature is 380℃. "P320" means purifier temperature is 320℃. "C385" means catalyst temperature is 385℃. "P" means pressure. "H0.50" means hydrogen pressure is0.50Bar. "C00.9" means pump pressure is 00.9Bar.
Standby phase	Hot Standby BAT 13.5V 00.0A	Hot Standby "BAT" means battery. And the followings are the battery voltage and current.
Shut down phase	Shutting Down Cool Down	Shutdown Press down key to check system information.
	T B380 P320 C385 P H0.50 C00.9	
	BAT 13.50V 00.0A	
Alarm interface	Press E to clear Low Fuel Alarm!	To remind methanol solution level low alarm message. It will not shut down the system Press Enter to clear the alarm and continue operating.

3.2.3 Air flow

The ECOBOX-MFC150 system filtered air inlet is on the front panel of the chassis. The unit's air exhaust is on the rear panel of the chassis.

An indoor rack installation should include room ventilation with sufficient filtered make-up air to provide adequate airflow to the unit. The system exhaust area should be always kept clear of debris and any flammables, and must be well ventilated to outside.

The ventilation system should be inspected annually and maintained free of obstruction for proper venting.

An indoor rack installation should include room ventilation with sufficient filtered make-up air to provide adequate airflow to the unit. And the air exhaust area should be always keeping fluent.

Either in an indoor rack installation, or a closed cabinet (indoor or outdoor), the air exhaust must be ducted outside to prevent the accumulation of humid air, which can condense on cooler surfaces.

3.2.4 DC Output +/-

The ECOBOX-MFC150 system should not connect to the load directly. You should connect to the load with a battery in the circuit. The battery provides capacity for load-following, and also enables some on-board functions to operate more rapidly during start-up.

WARNING

- DC terminals should always be considered electrified when connected to a DC bus.
- Observe proper polarity when connecting the power leads.

3.2.5 Circuit Breaker

The DC wires of ECOBOX-MFC150 system is provided with a circuit breaker that disconnects the unit from the bus. The high current draw which is over 60A will open the circuit breaker.

3.2.6 Fuel Level Sensor Connector

The ECOBOX-MFC150 system is provided with a fuel level sensor connector in the front panel that connects with the fuel tank to detect the fuel level. When the fuel level becomes too low, the sensor will send the signal to ECOBOX-MFC150 system, and the LCD display will show alarm information. However a low level alarm will not stop the unit operation, only showing in the LCD display. Press ENTER to clear the alarm information, and replenish the fuel.

4. Operation

WARNING

To avoid property damage, personal injury or loss of life, DO NOT attempt to operate the ECOBOX-MFC150 system until all directions have been read and understood.

Please use only IMPCA- grade ***pure methanol*** and de-ionised, demineralised ***distilled water*** for the fuel. The concentration by weight is ***62.5% Methanol to 37.5% pure water***.
When handling the Fuel, please keep the workplace well ventilated, clear of all sources of ignitions, spark or flame, avoid any contact with the Methanol fuel, use personal protection (gloves, breathing mask, Safety Glasses, long sleeves etc) to protect and prevent contact with the skin and eyes, and avoid breathing the vapours.

Check the integrity of the fuel lines before filling the tank, and pay careful attention to the connections to avoid any leakage. Check the fuel level in the tank and the fuel lines before running the system.

When running, the unit will operate in a similar way to a power-limited voltage source. The unit will supply power, attempting to achieve the output voltage. If the power limit of the unit is reached before the output voltage is achieved, the system will sustain its maximum power output. This maximum power output limitation may, for example, be at the rated value or less, due to temperature, altitude, reduced airflow (due to restrictions of intake or exhaust flow), reduced fuel flow (due to regulator pressure or hydrogen bleed obstruction), or fuel cell aging.

From start-up, a properly maintained ECOBOX-MFC150 system in heated standby will achieve 60% power in approximately one minute and peak power in approximately 10 minutes at 20°C at sea level. If heated standby off (system cold start), it will need 30 minutes more. This warm-up period is required for the fuel cell to heat itself sufficiently to evaporate the water created during the electrochemical process of making electricity and water from hydrogen and oxygen. Though the fuel cell could make full power almost instantly, doing so while cool would cause water to accumulate within the fuel cell, preventing gaseous hydrogen and oxygen (air) from reaching the reaction surfaces. Therefore, the system is controlled to make as much power as possible while allowing the water generated by the reaction to be evaporated to the atmosphere.

4.1 Methanol Connection

The fuel tank level should be at the level of the Methanol intake port. The fuel lines should be filled with methanol mix, and should have no air bubbles. DO NOT RUN THE PUMP DRY or with significant quantity of air in the lines, or the pump may be severely damaged.

4.2 Wire Connection

Figure 4-4 illustrates the detailed wiring connections for an indoor ECOBOX-MFC150 system installation.

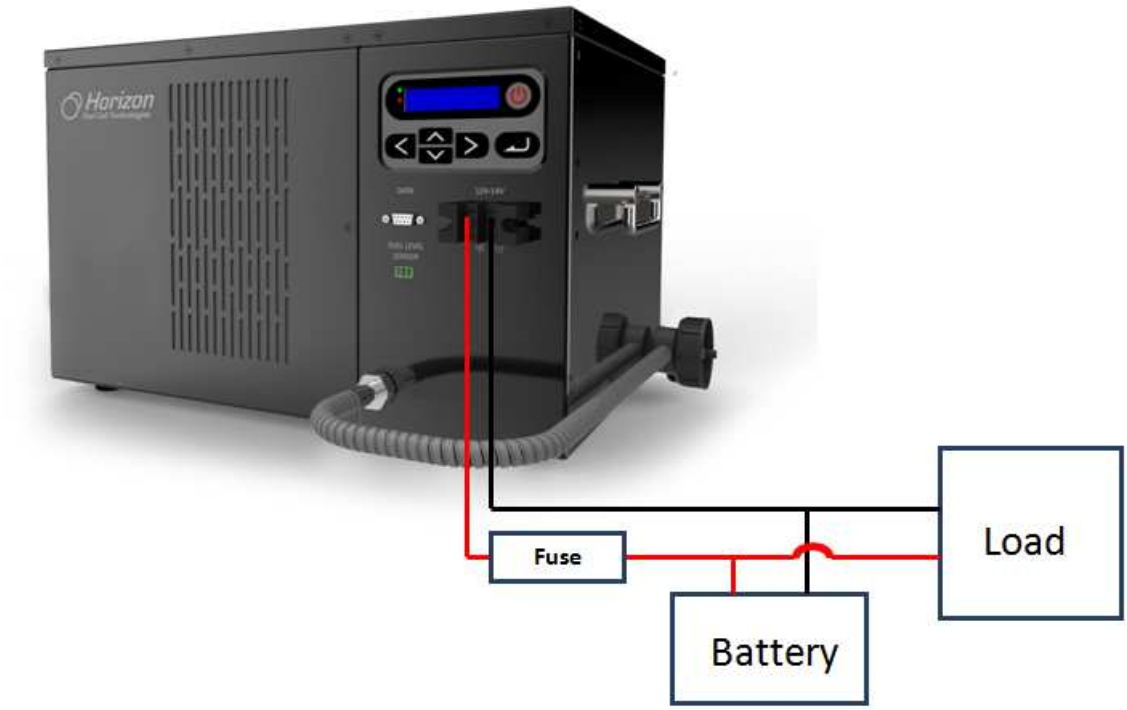

Figure 4-2. ECOBOX-MR25S1 system wiring connections

The minimum recommended external battery capacity for use with the ECOBOX-MFC150 system is one 100Ah lead acid battery for a 12V installation. This provides adequate buffering for system start-up and load fluctuations, and ensures protection for the battery string against over-discharge. The startup time will be 25 to 35 minutes when using lead acid battery, depending on ambient temperature.

4.3 Grounding

Using acceptable practices, as specified by NFPA 70 and National Electrical Code 250.166, connect a chassis ground wire to the chassis ground terminal provided on the ECOBOX-MFC150 system rear panel (Refer to Figure 4-3), and the screws on the rear panel of ECOBOX-MR25S1 stack can be identified as the chassis ground terminal(Refer to Figure 4-4). The ground wire size shall be a minimum of 10 AWG.

Figure 4-3. Grounding on controller

5. Applications Engineering

This section provides information to assist with the selection of the best-suited ECOBOX-MFC150 system configuration for the desired application. It also outlines site considerations for optimal fuel cell performance.

5.1 Storage Requirements

The ECOBOX-MFC150 system requires periodic operation or exercise in order to maintain proper hydration of the fuel cell stack. Horizon recommends that the ECOBOX-MFC150 system should operate at least 30 minutes per month. When not in operation, the system should be stored in controlled environments.

5.2 Site Requirements

WARNING

To avoid fire hazards, do not locate the fuel cell system next to stored gasoline or other flammable vapors and liquids. The system should have clear and clean airflow available, and the air intakes must not be restricted or the system may overheat or function in a derated condition due to over-temperature.

5.3 Load Engineering

When sizing the application both the actual site load and any additional heater load within the ECOBOX-MFC150 system due to cold environments should be considered. Site load should be determined by measuring the actual DC power output of the rectifiers during normal operation. Name-plate ratings of equipment should not be used to determine power requirements.

Appendix A: ECOBOX-MFC150 Specifications

ECOBOX-MFC150 Technical Specifications	
SYSTEM SPECIFICATION	ECOBOX-MFC150
Power Rating	0 to 150 W @ 20°C and 101.3 kPa
Voltage Adjustable	11-14 V DC
Voltage ripple	±1V
Controller Dimension(WxDxH)	470mm x 370mm x 300mm
Base Footprint(WxD)	470mm x 370mm
Total Weight	16.1 kg
Enclosure Material	Galvanized steel plate, powder-coated
OPERATION	
Power Conditioning	DC/DC converter
Cold Start Time Required	Approximately 30 minutes from 20C ambient temperatures
Cold Start Power Requirements	12 VDC, 400W for less than 25mins
Hot Standby Power Consumption	15W
Hot Standby Start Time	Less than 5 minutes
Fuel Consumption (Methanol/Water mix)	1.2L/KWH (62.5% Methanol)
EMISSIONS	
Reformer exhaust	CO2/H2 by-product, must be properly vented to outside atmosphere
Noise	<30 dBA@ 1m
Water	Approx 0.38L/kWh dependent on conditions, condenser kit available
CO, NOx, SOx	None
FUEL CELL SYSTEM	
Type	PEM
Coolant	Air
Efficiency	55% peak operating for fuel cell power module
Fuel Type & Specification	Methanol-Water mix. Mix ratio: 62.5% methanol, 37.5% deionized water by weight
Methanol Quality Requirements	99.85% purity, recommend Methanol compliant with IMPCA Specifications
Water Quality Requirements	Deionized water
Hydrogen Purity Delivered	99.99% pure hydrogen
Fuel Storage	External to System; Suitable Liquid Drums or Tanks
OPERATING ENVIRONMENT	
Operating Temperature Range	Start temperature range, rated power maintained -10 to 35C
Relative Humidity	0 to 95 % non-condensing

Recommended Altitude	<1,000 meters, 3280 ft
Shipping Freeze Exposure	Fuel cell stack non-operating / shipping exposure limit: -20C
Usage	Indoor/Outdoor stationary
CONTROLS & COMMUNICATION	
Software	Standard 76mm LCD & Keypad
Built-in User Interface	Standard 76mm LCD & Keypad
Built-in User Interface Connectivity	Serial port RS232, connect to computer, optional

Appendix B: ECOBOX-MFC150 Drawing